Component Testing System Vacuum Ring and Test Plate Construction

BACKGROUND OF THE INVENTION

1. Technical Field

[01.00] This invention relates generally to the batch processing of miniature electronic circuit components, including passive, two-terminal, ceramic capacitors, resistors, inductors, and the like. More particularly, it concerns a vacuum ring and a test plate that are used on a component testing system for holding such components or other type of device under test (DUT) as part of the batch processing for purposes of parametric testing.

2. Description of Related Art

[02.00] The tiny size of electronic circuit components of interest herein complicates processing. Typically fabricated of ceramic material in parallelepiped shapes having dimensions as small as 0.020" by 0.010" by 0.010" more or less, these difficult-to-handle components require appropriate equipment and precision handling techniques. During testing, such a component is sometimes referred to as a device under test (DUT).

[03.00] U.S. Patent 6,194,679 describes a testing machine for such DUTs. The testing machine in that patent is similar in some respects

to the testing machine available from Electro Scientific Industries, Inc. (ESI) of Portland, Oregon as its model ESI-3300. Among other things, the testing machine includes a component-holding part that is referred to herein as a "test plate" and a vacuum-communicating part that is referred to herein as a "vacuum ring." The test plate is mounted rotatably over the vacuum ring where it functions as means for receiving and hold a batch of DUTs. The vacuum ring (sometimes called a vacuum plate) couples a vacuum to the test plate that helps hold the test plate and load the DUTs onto the test plate. As the test plate rotates relative to the vacuum ring, various test are performed. After testing, DUTs are blown out of the test plate into various containers according to the test results.

[04.00] Although effective in many respects, there are some concerns related to the vacuum ring and the test plate. One is wear. Ceramic powder and loose ceramic pieces from DUTs can abrade the surface of the vacuum ring that faces the test plate. The vacuum ring, typically fabricated of nickel-plated steel, must eventually be replaced as a result (as much as two or three times a year).

[05.00] In addition, testing may involve voltages on the order of 1000 volts. Various forms of grease, grime, dirt, dust and other electrically conductive material on the vacuum ring and/or on the insulation material around the lower contact provide unwanted conductive paths. Arc-overs occur, and repeated arc-overs can damage the vacuum ring and even the expensive power supplies.

[06.00] DUT size differences introduce another concern. The vacuum ring includes what are referred to as eject holes or blow holes that are formed in the vacuum ring by milling, drilling, or other mechanical process. Compressed air coupled to an eject hole at just the right time serves to blow a DUT from the test plate into a sorting box according to test results. But, different size DUTs require different pressure (i.e., blowout force). Little DUTs require little eject holes for less blowout force while bigger DUTs require bigger eject holes for greater blowout force. As a result, various vacuum rings must be kept available and substituted on the test machine according to DUT size.

[07.00] Each of these concerns adds time and expense to DUT testing. Thus, a need exists for an improved vacuum ring and test plate construction so that the vacuum ring is more abrasion resistant, the vacuum ring is more arc-over proof, and differing DUT sizes are better accommodated.

SUMMARY OF THE INVENTION

[08.00] This invention addresses the concerns outlined above by providing a vacuum ring and test plate construction such that the vacuum ring and test plate include a base material (e.g., aluminum) and ceramic layer (e.g., alumina) covering the surface of the base material. The ceramic layer is hard and more abrasion resistant. It is also electrically non-conductive and more arc-over proof.

[09.00] In addition, one embodiment of the vacuum ring includes an eject hole that better accommodates different DUT sizes. The eject hole is actually a pattern of tiny laser-machined holes such that littler DUTs cover or occlude fewer holes for less blowout force while bigger DUTs cover more holes for greater blowout force (i.e., ejection force).

[10.00] To paraphrase some of the more precise language appearing in the claims and further introduce the nomenclature used, a vacuum ring for use in conjunction with a test plate on a component testing system includes a metallic base material that defines at least one vacuum-communicating passageway. The metallic base material has a test-plate-facing first surface and means are provided for improving abrasion resistance of the vacuum ring. For that purpose, a ceramic layer is disposed on the test-plate-facing first surface of the metallic base material.

[11.00] In one embodiment, the metallic base material is composed of aluminum and the ceramic layer is composed of alumina that is usually no less than 20 micrometers thick and no greater than about 100 micrometers thick. Preferably, the ceramic layer is bonded to the metallic base material by molecular adhesion using a micro-arc oxidation process.

[12.00] A test plate constructed according to another aspect of the invention for holding DUTs includes a DUT-holding structure that

defines at least one DUT-receiving hole. The DUT-holding structure is composed at least partially of a metallic material that has oppositely facing first and second outer surfaces. A ceramic layer disposed on at least the first outer surface of the DUT-holding structure improves abrasion resistance of the test plate. In one embodiment, the DUT-holding structure includes an internal wall that defines the DUT-holding hole and the ceramic layer (electrically nonconductive) covers both the first and second surfaces and the internal wall in order to enable use of the DUT-holding structure as a guard layer that is held at a selected electrical potential for testing purposes.

[13.00] According to yet another aspect of the invention, there is provided a vacuum ring for use in conjunction with a test plate on a component testing system for testing DUTs. The vacuum ring includes a base with an eject hole pattern for discharging compressed gas toward the DUTs in order to eject DUTs from the test plate. Each DUT has a cross sectional area less than a predetermined minimum cross sectional area and the eject hole pattern is sized accordingly. The eject hole pattern includes a plurality of closely spaced apart individual holes such that each of the individual holes has a cross sectional area that is somewhat less than the size that would be large enough to receive a DUT having the predetermined minimum cross sectional area. With that arrangement, the number of holes affecting a particular DUT for DUT ejection purposes is dependent on the cross sectional size of that particular DUT. The holes may take any of various forms, including being circular, oval, or elongate slots.

[14.00] Thus, the invention provides an improved vacuum ring and test plate construction such that the vacuum ring and test plate are more abrasion resistant, the vacuum ring is more arc-over proof, and differing DUT sizes are better accommodated. The following illustrative drawings and detailed description make the foregoing and other objects, features, and advantages of the invention more apparent.

BRIEF DESCRIPTION OF THE DRAWINGS

[15.00] FIG. **1** of the drawings is an exploded up view of some parts of a component testing machine, including a vacuum ring and a test plate that are constructed according to the invention;

[16.00] FIG. **2** is a cross sectional elevation view of a portion of the vacuum ring as viewed in a vertical plane containing a line **2-2** in FIG. **1**;

[17.00] FIG. **3** is a cross sectional elevation view of a portion of the test plate as viewed in a vertical plane containing a line **3-3** in FIG. **1**;

[18.00] FIG. **4** is a top plan view of an eject hole portion of the vacuum ring showing an eject hole pattern according to the invention;

[19.00] FIG. **5** is an isometric view of a typical DUT to be tested;

[20.00] FIG. **6** is a cross sectional elevation view of the eject hole portion as viewed in a vertical plane containing a line **6-6** in FIG. **4**;

[21.00] FIG. **7** is an enlarged diagrammatic representation of the eject hole pattern with two DUT sizes superimposed; and

[22.00] FIG. **8** is top plan view of another eject hole portion that combines circular holes and oblong holes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[23.00] FIG. **1** of the drawings shows a component testing system **10** that includes a vacuum ring **11** (a vacuum-communicating part) and a test plate **12** (a component-holding part) that are constructed according to the invention. The testing system **10** is similar in some respects to the testing machine described in U.S. Patent 6,194,679 and the testing machine in that patent is similar in some respects to the testing machine available from Electro Scientific Industries, Inc. (ESI) of Portland, Oregon as its model ESI-3300.

[24.00] The component testing system **10** includes what is sometimes called a base plate **13** on which the vacuum ring **11** is mounted. The test plate **12** mounts rotatably over the vacuum ring **11** where it functions as means for receiving and hold a batch of DUTs. The

vacuum ring **11** operates in conjunction with the test plate **12** in a known way to couple a vacuum source (not shown) on the component testing system **10** to the test plate **12** and DUT-holding holes in the test plate **12**.

[25.00] Thus, the vacuum ring **11** couples a vacuum to the test plate **12** that helps hold the test plate **12** and helps load the DUTs onto the test plate **12**. As the test plate **12** rotates relative to the vacuum ring **11**, various test are performed. For that purpose, upper and lower contactor assemblies **14** and **15** operate to electrically contact terminals on DUTs held in DUT-holding holes as the test plate **12** rotates.

[26.00] After testing, DUTs are blown out of the test plate **12** into various containers (not shown) according to the test results. However, as the test plate **12** rotates relative to the vacuum ring **11**, ceramic dust and particles from DUTs move across the vacuum ring **11** in an abrasive manner. The test plate **12** is similarly affected and so the abrasion resistance provided by this invention is desirable in order to limit replacement requirement.

[27.00] To achieve the desired abrasion resistance, the vacuum ring **11** includes a metallic base material **16** (e.g., aluminum) on which a ceramic layer **17** (e.g., alumina) is disposed (FIG. **2**). The base material includes a test-plate-facing first surface **16A** and an opposite second surface **16B**. In operation, the first surface **16A** faces upwardly toward

the test plate **12** while the second surface **16B** faces downwardly away from the test plate **12**.

[28.00] To function as a vacuum ring, the base material **16** defines at least one vacuum-communicating passageway **18**. The ceramic layer **17** is disposed on the test-plate-facing first surface **16A** so that the vacuum-communicating passageway **18** is exposed. So disposed, the ceramic layer **17** functions as means for improving abrasion resistance of the vacuum ring **11** by improving abrasion resistance of the first surface **16A**. Of course, the second surface **16B** (and other parts of the vacuum ring **11**) can also coated with a ceramic layer (not shown) for even more wear resistance and for convenience of fabrication.

[29.00] FIG. **2** is not drawn to scale. The thickness of the base material **16** and the thickness of the ceramic layer are exaggerated for illustrative purposes. However, the thickness of the illustrated base material **16** is about one-eighth inch while the thickness of the ceramic layer **17** fall is the a range of about 20 micrometers to about 100 micrometers.

[30.00] Preferably, the ceramic layer **13** is bonded to the metallic base material **16** by molecular adhesion. For that purpose, the illustrated ceramic layer **17** is formed on the metallic base material **16** by a known micro-arc oxidation process. The base material **16** is immersed in an electrolytic bath (water and highly dilute electrolyte) after which an electric current is applied to generate a series of micro-arcs on the

surface of the object that result in oxidation by micro-arcs. The micro-arcs pierce the layer of hydrated oxides covering the object, and the holes produced are then filled by the formation of a hard, ceramic-type oxide (the ceramic layer **17**) which, in the case of aluminum, is composed mainly of crystalline aluminum (i.e., alumina).

[31.00] The electrical process described above grows a somewhat thick, high quality ceramic layer **17** (on the order of 20 to 100 micrometers thick) on the base material **16**. Unlike the chrome and nickel plating processes, no metal is added, and there is no waste liquid to be processed. Furthermore, the coating is more robust than others, because the hard outer layer (i.e., the ceramic layer **17**) is bonded to the aluminum (the base material **16**) by molecular adhesion. Further details of the above process are available from Mofratech Company of Seynod, France under the trademark ALTIM TD. The process can also be used on titanium and magnesium.

[32.00] Turning now to FIG. **3**, it shows further details of the test plate **12**. The test plate **12** includes a DUT-holding structure **20** that defines at least one DUT-receiving hole **21**. The DUT-holding structure **20** (a base) is composed of a metallic material (e.g., aluminum) that has oppositely facing first and second outer surfaces **20A** and **20B**. The DUT-holding structure **20** could be multilayered so long as the first and second outer surfaces **20A** and **20B** are metallic.

[33.00] In a manner somewhat similar to that of the vacuum ring **11** described above, the test plate **12** includes means for improving abrasion resistance of the test plate in the form of a ceramic layer (e.g., alumina) having at least a first ceramic layer portion **22** that is disposed on the first outer surface **20A** of the DUT-holding structure **20**. Preferably, the first ceramic layer portion **22** is bonded to the first outer surface **20A** by molecular adhesion using the micro-arc oxidation process described above for the vacuum ring **11** with the result that the ceramic layer portion **22** has a thickness in the range of 20 micrometers to 100 micrometers.

[34.00] In addition, the test plate **12** includes an internal wall **20C** that defines the DUT-holding hole **21**. The ceramic layer includes a hole-covering second ceramic layer portion **23** that covers the internal wall **22C**. Similarly, a third ceramic layer portion **24** covers the second outer surface **20B**. That arrangement enables use of the the DUT-holding structure **20** as a guard layer that is held at a selected electrical potential for testing purposes, with the ceramic layer portions **22, 23,** and **24** providing an electrically nonconductive layer. For further details of a test plate with one or more guard layers, refer to United States Patent Application 20030197500 published October 23, 2003.

[35.00] FIGS. **4, 5,** and **6** show details of a vacuum ring **30** constructed according to the eject-hole aspect of the invention. The vacuum ring **30**

may be similar in many respects to the vacuum ring **11** described above, and the drawings are not to scale. The vacuum ring **30** is used in conjunction with a test plate on a component testing system (not shown in FIGS. **4-6**) for testing DUTs (e.g., the DUT **31** in FIG. **5**).

[36.00] The vacuum ring **30** includes a base **32** with an eject hole pattern **33** for discharging compressed gas toward the DUTs in order to eject DUTs from the test plate. Each DUT to be held by the test plate has a cross sectional area and the eject hole pattern **33** is sized accordingly. The cross sectional area of the DUT **31** is identified in FIG. **5** by reference numeral **34** to indicate that to which "predetermined cross sectional area" refers. The DUT **31** is not drawn to scale. It is greatly enlarged in FIG. **5** relative to the eject hole pattern **33** for illustrative convenience and the DUT terminations are shaded.

[37.00] The eject hole pattern **33** includes a plurality of forty-nine closely spaced-apart individual holes **35**, only one hole **35** being identified in FIGS. **4** and **6** for illustrative convenience. The cross sectional area of each DUT to be tested (e.g., typically as small as 0.010" by 0.010") is greater than a predetermined minimum cross sectional area, and the hole pattern **33** is such that each of the individual holes **35** has a cross sectional area that is somewhat less than the predetermined cross sectional area (i.e., somewhat less than the size that would be large enough to receive a DUT having the predetermined minimum cross sectional area). The illustrated individual holes **35** are circular, but a hole pattern with holes having any of

various other shapes may be used instead, including holes that are oval and elongate slots or spaced apart slits laser machined into the base **32**. An airway **36** that is drilled, milled, or otherwise formed in the base **32** of the vacuum ring **30** (FIG. **6**) serves to communicate compressed air to the individual holes **35**.

[38.00] In other words, the DUTs to be tested will not fit partially into the individual holes **35**, and the number of holes a particular DUT occludes is dependent on the size of that particular DUT. Stated another way, the number of individual holes **35** of the hole pattern **33** that affect a particular DUT for DUT ejection purposes is dependent on the cross sectional size of that particular DUT. As a result, the vacuum ring **30** works with DUTs having significantly different sizes.

[39.00] FIG. **7** illustrates the foregoing. It is an enlarged diagrammatic representation of the eject hole pattern **33** with two different sized DUTs superimposed. A smaller first DUT **31A** (the smaller square) covers just one eject hole so that a relatively small blast of air (i.e., ejection force) affects it for ejection purposes. A larger second DUT **31B** (the larger square) fully covers nine eject holes and partially covers an additional four eject holes so that a relatively large blast of air affects it for ejection purposes. FIG. **8** is top plan view of an eject hole pattern **40** that combines circular holes and oblong holes.

[40.00] Thus, the invention provides an improved vacuum ring and test plate construction such that the vacuum ring and test plate are more abrasion resistant, the vacuum ring is more arc-over proof, and differing DUT sizes are better accommodated. Although exemplary embodiments have been shown and described, one of ordinary skill in the art may make many changes, modifications, and substitutions without necessarily departing from the spirit and scope of the invention.

[41.00] What is claimed is: